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Influence of Biofertilizers on Flowering, Quality and Yield of Gerbera (*Gerbera jamesonii* Bolus) in Open Field Condition

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A B S T R A C T

An field experiment was undertaken at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during the period of 2015-2016 and 2016-2017. The experiment was laid out with 9 treatments in Randomized Block Design(RBD) and replicated 3 times. The Treatments comprised of T_0 (Control), T_1 {*Bacillus subtilis* (4% solution)}, T_2 {Microbacterium laevaniformans (4% solution)}, T_3 NPK (@15:10:20 g m-2), T_4 Vermicompost (5 kg per plot), T_5 (½ NPK + ½ Vermicompost + *Bacillus subtilis*), T_6 (½ NPK + ½ Vermicompost + Microbacterium laevaniformans), T_7 (½ NPK + ½ Vermicompost + Consortium) and T8 (Consortium). The results revealed that the flowering, quality and yield attributes were significantly influenced by the treatments. Most of the flowering, quality and yield characters were found highest in T_7. Early visibility of bud from planting was recorded in the treatment T_7 i.e., 61.09 days. This trend was reflected by early opening of bud (8.65days), days taken for early full bloom from bud opening (3.55 days), longer duration of flower (124.10 days), highest number of flowers per plant (34.33), highest flower diameter (9.78 cm), highest disc diameter (3.70 cm), length of flower stalk (50.37 cm), girth of flower stalk (0.66 cm) for T_7 respectively. The highest self life of flower (16.21 days) and highest vase life of flower (10.78 days) were recorded in treatment T_7 respectively. Likewise highest fresh weight of flower (12.85 g) and highest dry weight of flower (2.06 g) was recorded in treatment T_7 respectively.

Introduction

Gerbera (*Gerbera jamesonii* Bolus) belonging to family Asteraceae, native to tropical Asia and Africa is commonly known as Transvaal Daisy or Barberton Daisy is a flower with magnificent beauty, varying hues and colours. It is a dwarf tender stemless perennial plant having brilliantly coloured disc-shaped flowers and leafless stems. The genus Gerbera consists of forty species of semi hardy and perennial flowering plants (Bailey, 1963), the only species under cultivation is *G. jamesonii* with chromosome number n=25. The daisy like flowers are available in wide range of petal colours including yellow, red, orange, cream, white, pink, magenta, bricked, scarlet, salmon peach, maroon and various other intermediate shades. The colour variation, size of flowers, long lasting behaviour and wide adoptability made gerbera a flower of choice for cultivation in India. According to the global trends in floriculture, gerbera occupies the fourth place among the

top ten cut flowers in the world after rose, carnation and chrysanthemum (Choudhary and Prasad, 2009).

It is widely used as cut flower for presentation and interior decoration, garden plant, in landscapes as bedding plants for borders and flower beds and it makes a good showing in exhibitions and floral arrangements.

Steady decline in soil organic matter levels due to continuous cropping with injudicious applications of chemical fertilizers has lead to negative nutrient balances in Indian agriculture, impaired soil health and weaken factor productivity (Rao, 2007).

Recent studies have focused on traditional fertilization practices to enhance soil organic input by amendments of crop residues, biofertilizers, green manure, and farmyard manure. Selection of organic inputs characterized by a reliance on local agricultural bio resources is now in great demand because they are more cost-effective (Bhattacharyya *et al.,* 2008).

To meet the increasing demand, quantity as well as quality production is utmost essential. However such study on gerbera is very scanty in Assam condition. Maximization of flower yield with quality and extending vase life are of the prime importance in the cultivation of gerbera. Keeping all these aspects in view, biofertilizer has been identified as an alternative to chemical fertilizer in order to increase soil fertility and crop production in sustainable farming (Anandaraj and Delapierre, 2010).

Materials and Methods

The experiment was carried out at the Experimental Farm of the Department of Horticulture, Assam Agricultural University, Jorhat-785013 during the year 2015-17. The experimental soil was sandy loam in texture, well drained and having pH 5.1. The experiment was set out in a Randomized Block Design (RBD) which was replicated thrice. Cultivar Indukumari having uniform vigour and age were selected and planted on 15th of October in both the years of the study at a spacing of 30 cm x 30 cm.

The area of the experimental plot was 134.25 sq.m. and that of the individual bed was 1.5m x 1.5m (2.25 sq.m.) were raised to 25 cm from the ground level to avoid water stagnation. The crops were raised by following nine treatments in both the years.vThe Treatments were T_0 (Control), T_1 {*Bacillus subtilis* (4% solution)}, T_2 {Microbacterium laevaniformans (4% solution)}, T_3 NPK (@15:10:20 g m-2), T_4 Vermicompost (5 kg per plot), T_5 (½ NPK + ½ Vermicompost + *Bacillus subtilis*), T_6 (½ NPK + ½ Vermicompost + Microbacterium laevaniformans), T_7 (½ NPK + ½ Vermicompost + Consortium) and T_8 (Consortium). Where, as per recommendation package and practices fertilizers was applied at the time of field preparation. N, P_2O_5 and K_20 respectively which were applied NPK @15:10:20g m^{-2}. All the fertilizers were applied four days ahead of planting. Half of urea, full dose of SSP, MOP was applied at the time of basal dose. The second dose of N was applied at 30 days after planting.

Collected suckers were separated carefully from the mother plant. Before planting roots were trimmed off and one-thirds of the top portion of the leaves were cut off. Seedling root dip treatment was done with microbial consortium and kept for 15 to 20 minutes before planting. Suckers were then planted by maintaining proper spacing.

Observations on flower characters

Three representative flowers per plant were tagged for five sampled plants totaling fifteen flowers per plant. The same was repeated for each replication and the data was recorded.

Days to flower bud visibility

The date of first flower bud visibility was recorded and then converted to number of days taken for visibility of flower bud from planting.

Days to flower bud opening from bud visibility

The number of days taken for opening of first flower bud from flower bud visibility was recorded.

Days to full bloom from bud opening

The number of days taken by the first flower for full bloom from bud opening were counted and recorded.

Duration of flowering from 1st bloom to the last bloom (days)

The duration of flowering from the first bloom to the last bloom for each treatment was calculated by counting the number of days from the first flower bud showing colour till the last flower fading in that treatment.

Number of flowers per plant

The total number of flowers per representative plant from starting of flowering up to the final stage of flowering were counted and recorded.

Diameter of flower (cm)

Diameter of the three sample flowers was recorded at full bloom stage at peak flowering and the average was recorded.

Diameter of disc (cm)

Diameter of the central flower disc of three sample flowers was recorded at peak flowering and then the average was recorded.

Length of flower stalk (cm)

The length of the stalks from three sample flowers was measured from the base of the plant to the tip of the stalk below the flower head of each plant with the help of a meter scale and average was recorded.

Girth of flower stalk (cm)

Diameter of flower stalk was measured from three points (upper, middle and base) with the help of vernier calipers and then the average was recorded and expressed in cm.

Self life of flower (days)

The number of days required from half bloom to half fading of the flowers were considered as the self life and recorded accordingly.

Vase life of flower (days)

The sample flowers were harvested when the first two whorls of disc floret becomes perpendicular to the ray florets. It was done early in the morning and immediately the flowers were kept in a bucket of fresh water. Later, the flower stalks were cut to have uniform stalk length of 30 cm. Such prepared flowers were kept individually in flask containing 100 ml of distilled water. Flowers were observed daily till they were become half fading and found unfit for containing in vase. The vase life was expressed in terms of days from the date of harvest to final observation.

Fresh weight of flower (g)

Stalk of three sample flowers along with the flower head of each plant from the treatments. The weight was then taken in a digital weighing machine and the average was recorded. Final weight is recorded in g.

Dry weight of flower (g)

Dry weight of the flowers was taken by driving them at 60°C up to a point when two consecutive readings taken at two days interval gave same value.

All results were statistically analyzed using method advocated by Panse and Sukhatme (1995). When ANOVA showed significant differences, mean separation was carried out using critical difference (C.D) test at 5% level of significance to draw the valid conclusion.

Results and Discussion

Ultimate aim of any grower is to get higher yield, coupled with better quality to generate more revenue. Number of days for bud initiation and number of days for bud opening (Table: 1) was significantly decrease in T_7. This might be attributed to vigorous growth of the plants due to balanced nutrient levels in combination with biofertilizers, vermicompost and NPK results in early transformation of plant parts from vegetative to reproductive phase (Singh *et al.,* 2007 in rose, Renukaradhya, 2005 and Gangadharswamy, 2010 in carnation). Since phosphorus is an important element and essential for initiation of flowering, PSB along with vermicompost and NPK might have increase the availability of phosphorus which resulted in early flowering (Mantur, 1988). Presence of growth promoting substances such as GA_3 and cytokinin and bio fertilizers which makes ready availablility of nutrients along with presence of plant growth promoting substances might have lead to early flowering (Somasundaram *et al.,* 2004).

The number of days taken for full bloom from bud opening was significantly better in T_7. The earliness of flowering might be attributed to the presence of biofertilizers resulted in easy uptake of nutrients and simultaneous transport of growth promoting substances like cytokinins to the axillary buds resulting in faster flower opening (Somasundaram *et al.,* 2004). These results are in the line with the findings in marigold

(Chandrikapure *et al.,* 1999), crossandra (Narasimha and Haripriya, 2001) and limonium (Gayathri *et al.,* 2004). Similarly, it also helps in increasing the duration of flowering in T_7 (Table: 2).

Number of flowers produced per plant (Table: 3) was significantly highest in T_7. Increase in flower yield may be attributed to increased availability of phosphorous and its greater uptake due to application PSB (Kundu and Gaur, 1980).

Combination of biofertilizers and vermicompost along with recommended NPK produced higher flower yield in limonium (Gayathri *et al.,* 2004). Similarly, Chandrikapure *et al.,* (1999) reported higher flower yield in marigold due to combined applications of *Azotobacter* and PSB with 75 per cent recommended dose of nitrogen.

In presence of growth promoting substances such as GA and cytokinins, produced by growth promoting bacteria might be responsible for increasing the number of flowers. Vasanthkumar (2006) was attributed to huge quantity of microbial load and growth hormones which might have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately resulted in growth and yield of crops.

Cut flowers with larger flower diameter and disc diameter was recorded in T_7 (Table: 3). The increased uptake of phosphorus by PSB and the phytohormonal effects produced by biofertilizers might have resulted in higher diameter of gerbera flowers (Renukaradya, 2005 in carnation, Puttaswamy, 2004 and Prasanna, 2007 in gerbera).

Stalk length and girth of stalk (Table: 4) was recorded significantly higher in T_7. Higher stalk length might be due to better nutrient uptake, higher photosynthetic efficiency, source-sink relationship besides excellent physiological and biochemical activities due to the presence of PSB and vermicompost were reported by Swaminathan *et al.,* (1999) and Wang *et al.,* (1995). Growth promoting substances, particularly GA like substances in the plant growth promoting bacteria and bio stimulants might have also contributed to flower stalk elongation were obtained in carnation (Bhalla *et al.,* 2006 and Bhatia *et al.,* 2004), Padmadevi *et al.,* (2001) in anthurium, Bonita *et al.,* (1994) in gerbera and Singh *et al.,* (2007) in tube rose. Increase in girth of flower stalk might be due to application of vermicompost along with biofertilizers and NPK by Kale *et al.,* (1987). Also due to the mychorhizal root colonization, which enhanced availability of phosphorus by Nethra (1996).

Significantly maximum self life and vase life (Table: 5) in T_7. Longer self life may be due to longer stalk length and excessive accumulation of sugars in the stem which attributed to the development of water conducting tissues facilitated by bio fertilizers reported in china aster (Nethra, 1996), chrysanthemum (Hemavathi, 1997) and gerbera (Thane *et al.,* 2007). Growth promoting substances like cytokinins present in bio fertilizers might be responsible for longer self life (Narayanagowda, 2003).

Longer vase life may be due to better development of water conducting tissue and better absorption of water. Such improved vase life of flowers obtained from microbial inoculated plants were reported in several flower crops like gerbera (Prasanna, 2007 and Seetha, 1999), Anthurium (Padmadevi *et al.,* 2001), gladiolus (Kathiresan, 1999). Srivastava *et al.,* (2007) reported increase in vase life may be due to the availability of P to the plant which improves the quality of flower due to better phosphorelation in plants have helped in prolonging the post harvest life.

There was significant increase in the fresh weight and dry weight of flower (Table: 6) in T_7. Increased fresh weight might be due to increased availability of nutrients and increased mineralization and absorption of nitrogen reported by Johnson *et al.,* (1982) in *Chrysanthemum morifolium* and Bagyaraj and Powel (1985) in marigold. Also it might be increased due to biological fixation of nitrogen and phosphorus in root portion of plants resulting in absorption of more nutrients and its utilization (Bhalla *et al.,* 2006 in carnation). Increase in dry weight might be due to storage of carbohydrates and nitrogen compounds in the flower stalk (Flores *et al.,* 2007).

From the experiment it can be concluded that the treatment T_7 (½ NPK + ½ Vermicompost + Consortium) were found to be the most efficient treatment in terms of both yield and quality as well as for sustaining soil health.

Table.1 Days to bud visibility from planting and days to bud opening from bud visibility

Treatment	Days to bud visibility from planting			Days to bud opening from bud visibility		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T_0	78.80	74.50	**76.65**	15.62	15.08	**15.35**
T_1	71.67	70.87	**71.27**	12.92	12.03	**12.48**
T_2	70.30	69.60	**69.95**	12.32	11.92	**12.12**
T_3	68.23	65.74	**66.99**	11.12	10.67	**10.89**
T_4	66.10	62.80	**64.45**	10.22	9.67	**9.94**
T_5	65.15	62.33	**63.74**	9.63	9.20	**9.42**
T_6	64.43	61.73	**63.08**	9.50	8.83	**9.17**
T_7	62.13	60.05	**61.09**	8.97	8.33	**8.65**
T_8	69.37	68.57	**68.97**	11.80	11.03	**11.42**
S.Ed (±)	3.51	3.12	**2.44**	1.28	1.38	**0.92**
CD (5%)	**7.43**	**6.61**	**5.17**	**2.71**	**2.93**	**1.95**

Table.2 Days to full bloom from bud opening and duration of flowering from first bloom to the last bloom

Treatment	Days to full bloom from bud opening			Duration of flowering(days)		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T_0	6.27	6.22	**6.24**	92.33	94.40	**93.37**
T_1	5.67	5.60	**5.63**	98.60	98.93	**98.77**
T_2	5.60	5.20	**5.40**	100.33	101.47	**100.90**
T_3	5.13	4.87	**5.00**	109.07	112.20	**110.63**
T_4	4.93	4.54	**4.74**	114.67	115.00	**114.83**
T_5	4.07	3.99	**4.03**	118.33	119.32	**118.83**
T_6	3.93	3.74	**3.84**	119.43	120.94	**120.19**
T_7	3.77	3.33	**3.55**	121.33	126.87	**124.10**
T_8	5.27	5.60	**5.43**	102.67	106.08	**104.38**
S.Ed (±)	0.49	0.84	**0.55**	7.56	9.09	**4.35**
CD (5%)	**1.04**	**1.74**	**1.16**	**16.03**	**19.27**	**9.21**

Table.3 Number of flowers per plant, diameter of flower and disc

Treatment	Number of flowers per plant			Diameter of flower(cm)			Diameter of disc(cm)		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T_0	16.33	21.29	**18.81**	5.90	6.97	**6.44**	1.37	1.97	**1.67**
T_1	20.71	23.33	**22.02**	7.13	7.76	**7.45**	2.02	2.14	**2.08**
T_2	23.48	24.77	**24.13**	6.93	7.03	**6.98**	2.18	2.26	**2.22**
T_3	25.96	27.80	**26.88**	8.13	8.93	**8.53**	2.35	2.62	**2.49**
T_4	27.33	30.80	**29.07**	8.93	9.23	**9.08**	2.72	2.92	**2.82**
T_5	30.53	32.20	**31.37**	9.07	9.75	**9.41**	2.86	3.09	**2.98**
T_6	30.93	33.20	**32.07**	9.10	9.93	**9.52**	2.94	3.31	**3.12**
T_7	32.71	35.94	**34.33**	9.23	10.33	**9.78**	3.43	3.96	**3.70**
T_8	24.67	26.07	**25.37**	8.57	9.29	**8.93**	2.28	2.45	**2.37**
S.Ed (±)	2.04	2.71	**1.75**	0.85	0.81	**0.63**	0.33	0.41	**0.28**
CD (5%)	**4.32**	**5.75**	**3.70**	**1.79**	**1.72**	**1.34**	**0.71**	**0.86**	**0.59**

Table.4 Length and girth flower stalk

Treatment	Length of flower stalk(cm)			Girth of flower stal(cm)		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T_0	33.04	35.42	**34.23**	0.37	0.45	**0.41**
T_1	38.13	40.54	**39.34**	0.45	0.50	**0.48**
T_2	40.71	41.23	**40.97**	0.47	0.51	**0.49**
T_3	43.68	43.66	**43.67**	0.51	0.55	**0.53**
T_4	44.71	45.59	**45.15**	0.55	0.60	**0.58**
T_5	45.14	46.08	**45.61**	0.55	0.61	**0.58**
T_6	46.73	47.12	**46.93**	0.58	0.63	**0.60**
T_7	49.13	51.61	**50.37**	0.63	0.68	**0.66**
T_8	41.57	41.58	**41.58**	0.49	0.52	**0.51**
S.Ed (±)	2.98	3.10	**2.20**	0.04	0.05	**0.03**
CD (5%)	**6.32**	**6.56**	**4.67**	**0.08**	**0.11**	**0.07**

Table.5 Self life and vase life of flower

Treatment	Self life of flower(days)			Vase life of flower(dats)		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T_0	7.88	8.40	**8.14**	5.13	6.09	**5.61**
T_1	10.85	10.90	**10.87**	6.91	7.22	**7.07**
T_2	10.92	11.67	**11.29**	6.67	7.74	**7.21**
T_3	13.40	13.80	**13.60**	7.69	8.22	**7.96**
T_4	14.00	14.60	**14.30**	8.10	8.64	**8.37**
T_5	14.60	14.82	**14.71**	8.56	8.93	**8.75**
T_6	15.33	15.73	**15.53**	8.89	9.03	**8.96**
T_7	15.80	16.62	**16.21**	10.33	11.22	**10.78**
T_8	11.73	12.93	**12.33**	7.92	8.98	**8.45**
S.Ed (±)	1.53	2.23	**1.23**	1.16	1.05	**0.94**
CD (5%)	**3.24**	**4.73**	**2.60**	**2.45**	**2.22**	**2.00**

Table.6 Fresh weight and dry weight of flower

Treatment	Fresh weight of flower(g)			Dry weight of flower(g)		
	2015-2016	2016-2017	Pooled	2015-2016	2016-2017	Pooled
T_0	9.48	9.76	**9.62**	1.31	1.44	**1.38**
T_1	10.27	10.72	**10.50**	1.55	1.66	**1.61**
T_2	10.47	10.92	**10.69**	1.60	1.62	**1.61**
T_3	10.67	11.22	**10.94**	1.71	1.76	**1.73**
T_4	11.94	11.71	**11.83**	1.75	2.15	**1.95**
T_5	12.01	12.17	**12.09**	1.76	1.78	**1.77**
T_6	11.88	12.39	**12.14**	1.84	1.80	**1.82**
T_7	12.60	13.10	**12.85**	1.98	2.14	**2.06**
T_8	10.63	11.02	**10.83**	1.71	1.67	**1.69**
S.Ed (±)	0.90	0.88	**0.83**	0.13	0.15	**0.11**
CD (5%)	**1.92**	**1.86**	**1.77**	**0.28**	**0.32**	**0.23**

Hence, this treatment may be placed under multi-location trials in farmer's field to judge the efficacy for commercial cultivation of gerbera by reducing the quantity of chemical fertilizers in different agro climatic zones to improve the soil structure and texture, reduces soil pollution, reduced extensive fertilizer application which is beneficial for the present problems of high cost of fertilizers and environmental pollution.

Author Contributions

Nilasree Borah: Investigation, formal analysis, writing—original draft.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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